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New Framework of Intelligent Evacuation System of Buildings

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Abstract

On the basis of the analysis about the traditional evacuation and lifesaving facilities, this paper adopts high-tech technological means (e.g. advanced intelligent information-monitoring technique, artificial intelligent technique, computer technology, etc.), integrates the function of building evacuation, and establishes an intelligent evacuation system. This system overcomes the disadvantages and defects of the current intelligent evacuation system, and realizes the intelligent dynamic guidance of the personnel evacuation under the real fire scene through the main control module of the intelligent evacuation system. It aims to actually realize the intellectualization according to the dynamic change of the fire scene, and make the personnel evacuation more scientific, rapid and safer.

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Keywords: fire control, high-rise intelligent building, intelligent evacuation system, systematic framework, information acquisition

1. Preface

With the rapid development of the economy, science and technology, efficient utilization of the ground space has already become an inevitable trend of the urbanization construction. In recent years, the urban buildings gradually develop towards the high-rise and intelligent buildings.

This paper analyzes the disadvantages and defects of the current intelligent evacuation system. On this basis, it utilizes the intelligent development trend, and blends high-tech technological means (e.g. advanced intelligent information-monitoring technique, artificial intelligent technique, computer technology, etc.) into the evacuation system, and integrates the function of the building evacuation. Through the analysis on the information demands of the intelligent evacuation system and on the basis of the development level of the current information acquisition technology, it verifies the feasibility of the system realization. Finally, it establishes an intelligent evacuation system, which enables the evacuation system to become an organic integrity, and makes the personnel evacuation under the real fire scene to be a scientific, reasonable and integrated intelligent dynamic adjustable system, with the purpose of improving the evacuation efficiency and making the personnel evacuation more well-organized, rapid and safer.

2. Status analysis of the intelligent evacuation system of the buildings

2.1 Disadvantages of the current intelligent evacuation system

The emerging of the intelligent emergency lighting, the evacuation indication and escape system, and the escape system of the intelligent elevators brings vitality to the research on the intelligent of the personnel evacuation [4][7].

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With regard to the current research status in China, the intelligent system of these two branches still rest on the fixed model of "warning — judgment — planning to escape". Namely, the single smoke detector is widely adopted to detect the occurrence of the fire. Then, the intelligent judgment system is applied or the personnel judge the occurrence and development of the fire. Finally, the indication system is adopted to evacuate the crowd. Such model is still the personnel evacuation process that is planed and arranged in advance. However, the characteristics of the buildings and the group characteristics of the personnel are not taken into full consideration. Moreover, the situation of the actual fire propagation is neglected. Therefore, no matter for the intelligent escape system (e.g. intelligent control and static simulation of the computer, etc.) or the pre-established contingency plans, it is impossible to dynamically adjust the routes of the personnel evacuation and completely avoid the existing defects according to the actual status of the fire propagation in the fire scene.

The current intelligent emergency lighting, evacuation indication escape system, as well as the escape system of the current intelligent elevator, collect fire information by the means of setting smoke detectors on the stair landing of each storey, which causes that the front-end fire information acquisition of the intelligent indication system only exists in the established specific area and short time quantum. As a result, it is absolutely impossible to have full understanding of the overall information of the fire development. In addition, almost all detectors are based on single threshold value. Namely, the usage of the detector is disposable. Apart from detecting the fire at the beginning, the detector basically has no effect after the continuous propagation of the fire. Its function is limited in the specific condition of the fire. Consequently, the intelligent system can only present its superiority within short time. When it is not feasible for the front-end information acquisition of the system to update the informed content, the intellectualization will lose its significance [6][7].

With regard to the escape in a fire, the most importance is to have accurate judgment on the propagation of the fire. It not only relies on some single or compound detectors, but also requires diversified information to carry out comprehensive analysis and accurate judgment on the fire propagation and personnel evacuation, so that it is feasible to dynamically and efficiently lead the personnel to escape from the safe regions according to the status and trend of the fire propagation. Meanwhile, it is necessary to consider some relevant factors, such as the structure features of the buildings, the features of the crowd evacuating, application status of the fire control facilities of the buildings, etc. All of them are the major factors influencing the fire propagation and crowd evacuation.

In general, there is no complete intelligent evacuation system in the domain of personnel evacuation at present. All safe evacuation facilities cannot give full play to their own advantages. Besides, they cannot be organically integrated and applied. They only can realize the primary function of linkage. However, they cannot carry out intelligent analysis and dynamic adjustment, and cannot get through the whole evacuation process, etc. Especially, it is necessary to have further discussion on the holistic research of the complex system with the combination of buildings, fire, crowd, and evacuation intellectualization.

2.2 Functional characteristics of the ideal intelligent evacuation system

The main purpose of this paper is to take full advantage of the existing mean about the buildings (e.g. advanced digital technology and information technology, fire safety science and technology, network technique, simulation technique of the computer, artificial intelligence technology, etc.) on the basis of various traditional safe evacuation and refuge facilities with fixed form, dependent and single function; integrate the evacuation function of the buildings; to establish an ideal intelligent evacuation system; to form a scientific and controllable intelligent system. It is aimed at realizing scientific, reasonable, safe and rapid evacuation. The ideal intelligent evacuation system should contain the following innovation:

A. Having intelligent fire information monitoring system with more improved function

It should contain more information technology means with more innovation and superiority. Besides, it should obtain more comprehensive, accurate and real-time dynamic information about the occurrence, development and propagation of the fire. Moreover, it should realize the real-time monitoring and transmission of the detailed characteristics (especially the characteristics which have significant impact on the personnel evacuation) (e.g. smoke density, temperature, toxicity, etc) and the dynamic information of the personnel evacuation (e.g. personnel distribution status, congestion and clustering part, the location of the personnel who cannot be evacuated normally, etc.).

B. Having intelligent main (center) control judgment system

The information about different personnel evacuation acquired through the intelligent fire information monitoring system should be reflected and summarized in a main (center) control platform. This platform should process, analyze and summarize the real-time information of various fires. By virtue of the information, it carries out comprehensive judgment through the great specific arithmetical operation rules, obtains results, and generates scientific and accurate evacuation commands. What's more, it can adjust the evacuation plans intelligently, dynamically and promptly. It has sensitive sense and the ability of core intelligent judgment as the robot. Furthermore, it is safe and reliable, with zero error.

C. Having the intelligent emergency lighting and evacuation indication system with more superior performance

Through the communication system, the evacuation command is transmitted to the intelligent emergency lighting and the main engine of the evacuation indication system in real time. The main engine conducts the command and then transmits it to each system node (each light). The light should have multiple functions. Apart from the traditional emergency lighting and evacuation indication, it is feasible to develop different display devices and indication devices, and integrate the function of voice guiding. By the virtue of new technology means (e.g. stroboflash, etc.), the emergency lighting and evacuation indication system, as the front-end display devices, indirectly transmit the real-time information of the fire scene

to the evacuated crowd, so as to help the crowd to overcome the panic and guide them to evacuate rapidly, reasonably and safely.

D. Having the ability of integrating and reasonably applying the advantage of other information technology to the intelligent buildings

Like the audio frequency, video technique, networking technology, wireless communication technique, etc., give full play to the superiority of the high-tech technology, such as voice guide, video monitoring, wireless transmission, etc.; take full advantage of the existing intelligent technology of the buildings so as to better blend the fire extinguishing system into the intelligent system of the buildings; realize the integration of the building intellectualization and obtain better technology service.

3. Framework of the intelligent evacuation system of the buildings

The principle line of the main idea to construct the framework of the intelligent evacuation system is as follows:

On the basis of the evacuation lifesaving system of the buildings, establish a system which takes the front-end information acquisition as the data source, the main control module of the intelligent evacuation system as the core, the intelligent emergency lighting and evacuation indication escape system as the front-end display device, and guiding the stream of people and fixing the evacuation facilities as the carriers, with the purpose of evacuating the personnel. Establish and utilize the scientific and application results of the superior information technology, and intelligent and dynamic adjustable system of the intelligent buildings. This system is available to be implanted with the intelligent main engine system of the intelligent buildings and be contained in the building automation system (BAS). Moreover, it will organically combine with the communication network system (CNS) and office automation system (OAS), and then become a part of the building intellectualization technology.

The basic motion procedure of the system is as follows: take the content acquired from the front-end information acquisition as the data source, input the data to the main control module of the intelligent evacuation system embedded in the main intelligent engine of the buildings. Through the operation of the background and after generating the command, output it to the intelligent emergency lighting, evacuation indication and escape system; directly guide the crowd to conduct the personnel evacuation by adopting the fixed evacuation devices of the buildings as the carriers through its front-end display device (voice, stroboflash, two-way adjustable indication, luminous flux indication, digital display, etc.). Among them, the front-end information acquisition provides necessary basis support for the system, while the main control module of the intelligent evacuation system is the core of the system.

Sketch of intelligent evacuation system composition of the buildings is shown in Fig. 1.

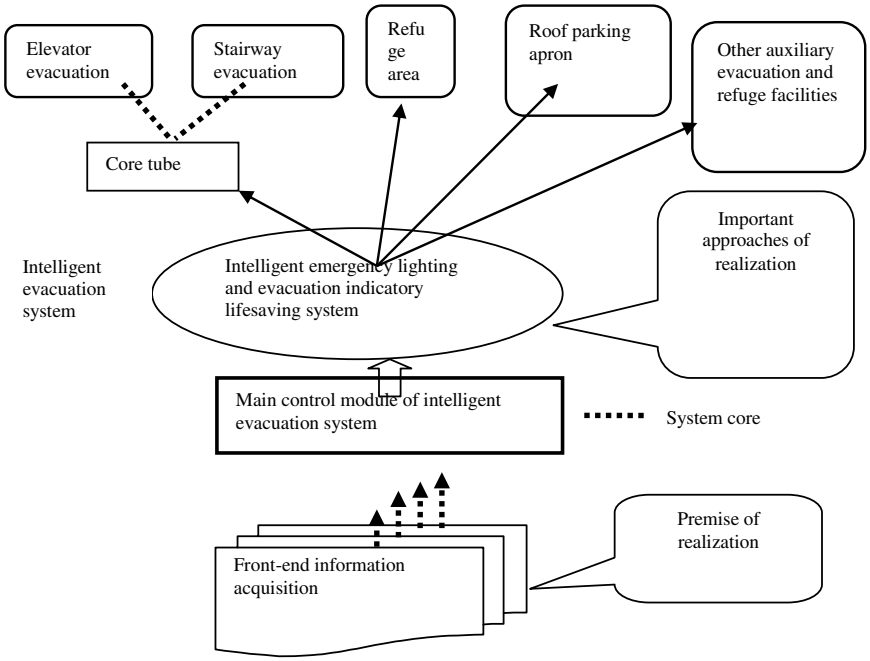

Fig. 1. Sketch of Intelligent Evacuation System Composition

3.1 Front-end information acquisition system

The combination of the technology of the front-end information acquisition and the function of the intelligent automatic fire-warning system constitutes the front-end information acquisition system. Such system is the source and necessary basic data report for the realizing the intelligent evacuation system.

The front-end information acquisition system with the function of the intelligent automatic fire-warning system includes the information acquisition of the fire detection and fire propagation, personnel distribution information, on/off status of the mechanic smoke control system, and all information acquisition related to the personnel evacuation.

Fire detection: apply the research achievements of the early and ultra-early detection technology, find out and confirm the occurrence of the fire in the ignition area, and give warning for one time; the personnel begin to evacuate.

Fire propagation: that the dense smoke and flame start to spread from the room, aisle to the core tube will exert threat on evacuating the personnel on the storey with fire. At this time, it is feasible to utilize the various sensors (e.g. smoke density sensor, temperature sensor, toxic gas sensor, etc.) set in different specific height along the aisle to come into play. At the same time of identifying the accurate propagation direction and speed, when the test results can reach the established value, the secondary warning information will be generated. The personnel evacuation needs to refer to the warning information and conduct the routing selection.

Personnel distribution information: take advantage of the personnel counting device and video monitoring device installed on the bottleneck points of the evacuation routes (e.g. the interchange of the evacuation exit, turning, core tube, stairway, etc.) and the technology means (e.g. wireless sensor networks, etc.), and obtain the number of the personnel of each bottleneck point, and the information about the status of personnel evacuation, clustering and blocking, and other real-time information.

On/off status of the mechanic smoke control system: the mechanic smoke control system has impact on the fire smoke, and its on/off status also influences the personnel evacuation.

The transfer of all information related to personnel evacuation, general automatic warning control mould with real-time disaster, and the general control module of the intelligent evacuation system.

The realization of the acquisition part of the front-end information is shown in Fig. 2.

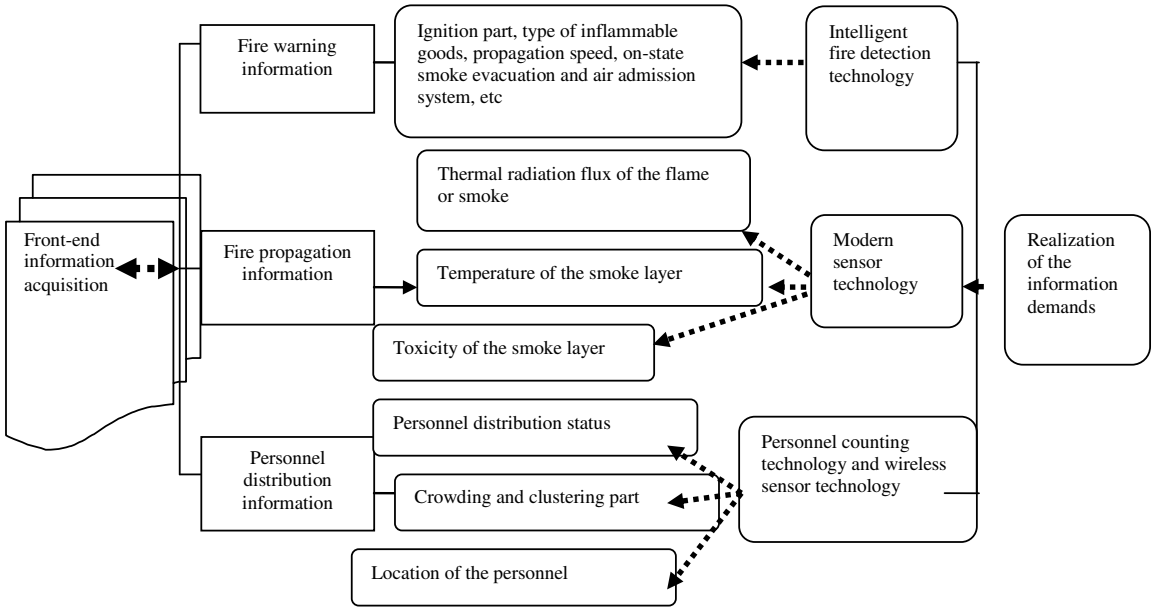

Fig. 2. Framework Chart of Front-end Information Acquisition

The multilevel detection is taken into account here. Xie Hua and Zhou Chao from Shenyang Institute of Aeronautical Engineering have thought about the multilevel detection. The greatest advantage lies in the grading processing towards the information collection about the fire scene. However, according to the warning sequence of the detector and the successive location of the damage, it is feasible to judge the fire origin and the fire propagation trend, which plays a significant role in the personnel evacuation. Especially, on the route of the propagation trend, if there is danger source, it is more necessary to avoid it.

In addition, due to the further combination of fire detection technology, automation and modern communication system

and intelligent building technology, the fire detection system tends to be more automatic, open and modularized. It will also become the only route for development.

3.2 Main control module of intelligent evacuation system

The main control module of the intelligent evacuation system is the core of the whole system. The main control module contains several sub-models that are embedded in the module and determine the generation of the intelligent command. Each sub-model represents the basic principles and basis of the intelligent command generation. They also have their own model equation, namely, the arithmetical operation. Besides, the achievement of the model equation should have fire science theory, fire risk evaluation methodology and other related ones as its theory basis and support, which not only can lay solid foundation for truly simulating the intelligent evacuation system and guiding the personnel evacuation, but also can reflect and verify the scientificalness, rationality, and effectiveness of the established intelligent evacuation system. Thus, it is feasible to put forward new thought on studying personnel evacuation and obtaining optimized personnel evacuation proposals. The composition of the main control module of the intelligent evacuation system is shown in Fig. 3.

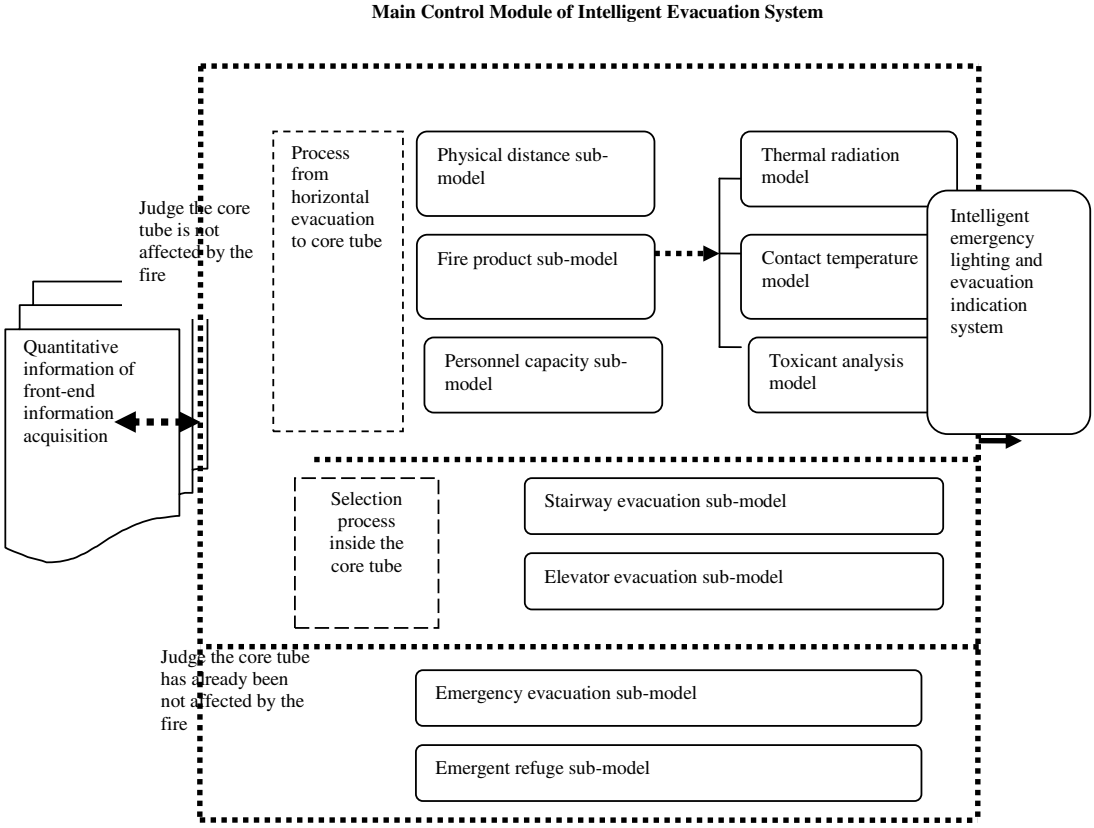

Fig. 3. Main Control Module Composition Chart of Intelligent Evacuation System

3.3 Intelligent emergency lighting and evacuation indicatory lifesaving system

The intelligent emergency lighting and evacuation indicatory lifesaving system are important front-end display devices for realizing the function of intelligent evacuation system. The system still adopts fire-control evacuation indicatory sign lamp with different functions on the basis of the current system. In addition, through the integration of stroboflash, voice, two-way adjustment, and vision-succession signal lamp, it strengthens the signal from the sensory organs (e.g. vision, hearing, etc.) of the evacuation personnel, which is favourable for the personnel to escape from the fire scene. The integration of the front-end information acquisition with the intelligent fire alarming system enables the intelligent emergency lighting and evacuation indicatory escape system to obtain comprehensive and accurate information. What's more, it can obtain relevant dynamic information in real time when the status of the fire scene changes. After the background operation of the main control module of the system, it can generate optimal safe evacuation routines through intelligent judgment, and adjust the evacuation guiding direction of the evacuation lamps in the buildings in real time.

The abundant technology of front-end information acquisition enables the intelligent evacuation indicatory escape system to separate from the initial version which only can realize the initial function (e.g. linkage, etc.) and cannot carry out intelligent analysis and dynamic adjustment, as well as incapability of being running through and applied in the whole evacuation process. Thus, it can actually achieve the purpose of guiding the personnel to escape from the fire region "safely, accurately and rapidly".

In addition, the effect of the new intelligent emergency lighting and evacuation indicatory escape system should run through the whole process from the initial-phase escape, metaphase refuge to the last-phase rescue. Besides, the partition setting problem of the module should be taken into account. Once the lamp of some part is damaged due to the fire, the normal operation of the whole system should not be affected. Therefore, it is necessary to delay the effect time of the intelligent emergency lighting and evacuation indicatory escape system.

Various advanced voice system and fire scene information display devices are indispensable in the intelligence emergency lighting, evacuation indication and escape system. For instance, it is necessary to set voice guidance devices on the evacuation route and specific position inside the core tube; set monitoring information display screen of the core tube in the necessary parts (e.g. pre-chamber of the core tube, etc.) so as to display the real-time status information, elevator arrival time, the number of the people who are waiting, etc.; set a screen for displaying the real-time elevator status in the elevator, etc.

3.4 Optimal utilization of the fixed evacuation facilities of the buildings

The fixed evacuation and lifesaving facilities of the buildings contain the core tube, refuge layer (chamber), roof parking apron, auxiliary evacuation facilities, emergency lighting, evacuation indication system, etc. That all of these infrastructures reach the best status during the setting is the basis for the intelligent evacuation system to be utilized fully, effectively and accurately.

4. Conclusions

As for the evacuation system of the future buildings, the intellectualization is an indispensable feature. It not only realizes the linkage relationship among the single product, but also, more importantly, possesses the response process similar to the human brain, such as automatic signal processing, background data infusion and calculation, judgment command generation, dynamic adjustment about the front-end display, etc. This paper carries out investigation on the evacuation-related intelligent emergency lighting, indication system and intelligent elevator system which emerge in recent two years, so as to comprehend their superiority and advancement. Meanwhile, it analyzes and studies the existing defects and shortcomings of the existing systems. Through importing high-tech technology (e.g. intelligent fire monitoring system and front-end information acquisition technology, etc.), it solves the existing problems of the existing system that only can realize the initial functions (e.g. linkage, etc.), and cannot carry out intelligent analysis and dynamic adjustment, as well as incapability of being applied during the whole evacuation process. Through integration of the evacuation function of the building, it is feasible to establish an intelligent evacuation system. Moreover, it describes the movement process and principle of the intelligent evacuation system in detail, including the methods and means for realizing the intellectualization, which provides possibility of realizing the system intellectualization. After the framework is established, it is feasible to make mathematical modeling for the intelligent evacuation system and provide specific arithmetic rules for realizing the intellectualization, so as to make the system complete and feasible.

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